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THE UTILIZATION OF SURPLUS PLUMS

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THE UTILIZATION OF SURPLUS PLUMS

W. V. CRUESS

Most of the plums grown in California are marketed in the fresh condition, but owing to the fact that special qualities are necessary for this purpose, much fruit is left on the trees, or is sorted out as culls at the packing houses.

Estimates by Farm Advisor McCallum and others place the average amount of cull plums in Placer County at about 3000 tons. Placer County had in 1924 approximately 7,350 acres of bearing plums, according to statistics of the State Department of Agriculture, and the remainder of the State approximately 21,400 acres. Assuming that the amount of culls to the acre is the same for other plum districts as for Placer County, the total quantity of cull plums would be about 12,000 tons annually.

At present only a very small proportion of the cull plums is utilized; jam factories in California being the principal users. Some plums are used locally in the home for jams and jellies, but the total so used is insignificant. If a market for the low grade fruit for use in by–products could be developed, it would result in great benefit to the industry, both directly by increasing returns and indirectly by preventing the marketing of inferior fruit.

In October, 1922, the University was requested by a committee of the Farm Bureau of Placer County to study methods of utilizing surplus plums. In answer to this request experiments were made at Berkeley and at Lincoln during the 1923, 1924 and 1925 seasons.

Acknowledgments.—All of the experiments under factory conditions were made in the cannery of the Placer County Fruit Growers' Canning Association at Lincoln, of which E. J. Fereva is general manager, and H. C. Gordon, superintendent.

A. Fereva, foreman of cutting room and T. Richards, foreman of the cook–room actively coöperated in the experiments. Thanks are due A. W. Christie of the Fruit Products Laboratory for data on the dehydration of cull plums, and J. H. Irish for observations made in 1923 on the canned and bottled samples of plum products stored at Berkeley. Acknowledgement is made to R. D. McCallum, Farm Advisor of Placer County for his coöperation throughout the experiments and to the Placer County Fruit Growers' Association of Lincoln, J. A. Teagarden and others for fruit used.

Freezing Storage.—Fruit preserving factories use, in the preparation of jams and jellies, large quantities of berries preserved by freezing. The barreled berries are distributed in the frozen condition throughout the United States from cold storage warehouses located in berry districts.

Since plums are very satisfactory for use in jams, jellies and butters, and, like berries, are very perishable in the fresh state, it was thought that they might be stored and distributed successfully in the frozen condition.

Approximately equal quantities of cull President, Giant and Grand Duke plums were mixed. The fruit used was in sound condition, but varied in maturity from hard green to soft ripe.

Experiments with other fruits had proved that fruit preserved by freezing must be covered with liquid in order to minimize darkening of the color. Water could be added to the whole fruit, but would greatly dilute the product. The natural juice of the crushed plums, however, has no such objection. The best method of crushing found consisted in passing the plums through an apple crusher with the crushing rolls so adjusted that the flesh of the plums was crushed without breaking the pits.

Crushing liberated enough juice to completely fill the spaces between the pieces of fruit and gave a "solid" pack.

Number ten cans and a five gallon and a ten gallon keg were used. The kegs were filled after removing one head. After filling, this was replaced and the hoops driven into place. The cans were filled and sealed without exhausting or heating.

The sealed containers were placed in the freezing room of the Pomology experimental cold storage plant at Berkeley. Resistance thermometers were placed in the center of one container of each size and readings made at intervals on a potentiometer placed outside the cold storage room.* The purpose of the test was to determine whether the rate of cooling would be rapid enough to prevent fermentation when fruit packed without previous precooling is used. In figure 1 will be found the cooling curves. Cooling was rapid until the freezing point, about 28.5° F., was reached. The temperature in the kegs remained at this point for several hours, probably, as suggested by F. T. Bioletti, because the latent heat of fusion absorbed during freezing temporarily arrested the drop in temperature.

The cooling was sufficiently rapid under the aforementioned conditions to prevent fermentation of sound fruit. A 50 gallon barrel

* The temperature measurements were made by George Marsh.

packed with another variety of fruit was also found to cool sufficiently rapidly to preclude spoiling.

On removal from cold storage, the frozen fruit thaws very slowly; a 50 gallon barrel of other fruit contained some ice one week after removal from the cold room. The barreled fruit could, therefore, be shipped considerable distances by ordinary freight without refrigeration.

After several months' storage the frozen fruit was found to be equal in value to the fresh for use in jam, buter, and jelly.

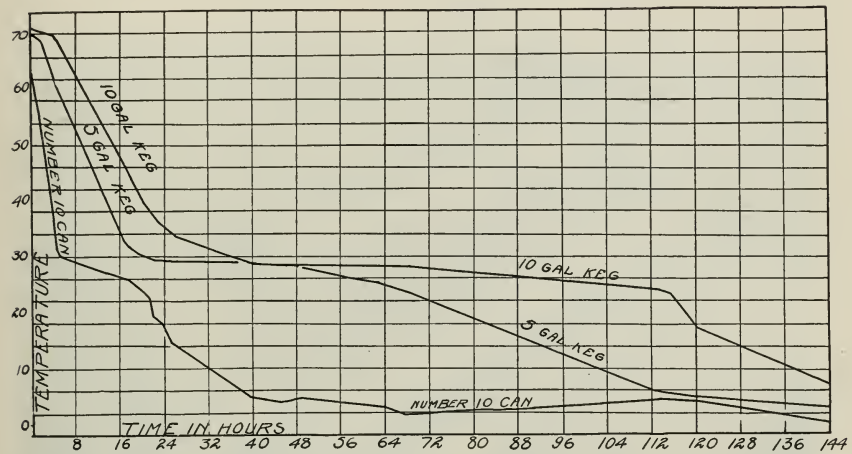

Fig. 1.—Curves showing the cooling of crushed plums in three sizes of containers stored at about 0° F.

Storage at 32 F.—During two successive seasons, cull plums were taken direct from the fresh fruit packing house in Lincoln and stored in 50 pound lug boxes at 32° F. in the Lincoln Cannery's cold storage room. Some loss from the molding of overripe fruit occurred and sorting and washing at the time of removal from storage was necessary. The cold-stored fruit after about five weeks' storage was found thoroughly satisfactory for the preparation of all of the products described in this publication.

Storage at 32° F. could be used as a means of accumulating sufficient cull fruit to warrant operation of a by-products factory in localities where only a relatively small amount of any one variety of plums is available at one time, but where the agregate of all varieties is relatively large.

Plum Jam and Butter.—It was found by extensive trials with culls of the more important varieties of plums grown in Placer County that excellent plum butter and jam could be made. In small scale

experiments the single varieties were used for each test; in factory scale experiments, several varieties were mixed. In factory practice, it would be necessary to mix the different varieties in order to obtain a finished product of uniform character.

The cull plums were first carefully sorted to remove rot. They were then transferred to a large steam jacketed copper kettle and washed thoroughly with cold water. Water at the rate of about 6 gallons to 300 pounds of the fruit was added; this was enough to prevent scorching during cooking. The fruit was boiled until well softened, that is about 15 minutes.

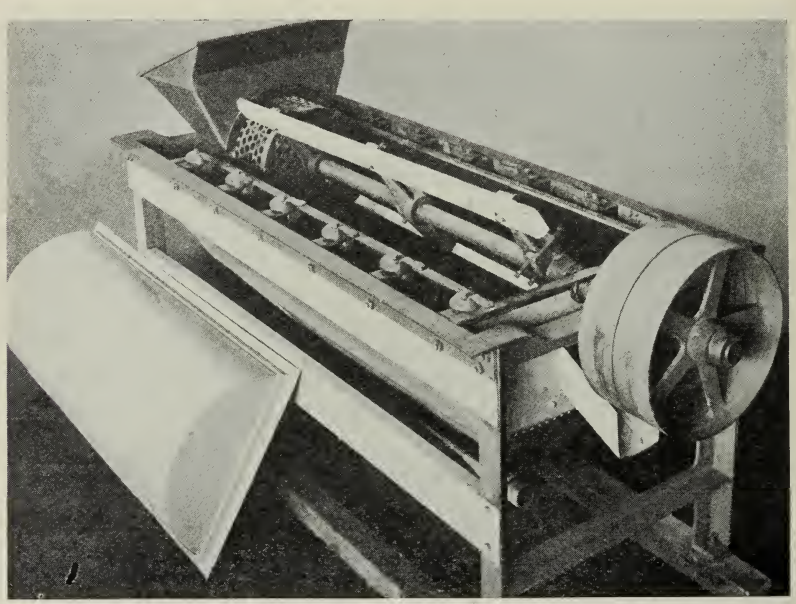

Fig. 2.—Pulper. Used for separating skins and seeds from pulp and juice. (Courtesy Anderson–Barngrover Company). A similar pulper is also made by the Smith Manufacturing Company.

It was then passed through a large Anderson-Barngrover tomato pulper operated at about 300 R. P. M. See figure 2.

In the pulper the juice and pulp were separated from the seeds and skins by means of a heavy copper screen against which the fruit was thrown and rubbed by revolving paddles. It was necessary to set the paddles of the pulper at a sufficient distance from the screen to prevent rupture of the screen by the pits. If the pulper were to be used continuously on plums, it would be advisable to install a very heavy screen because the abrasive action of the plum pits on the average tomato screen is severe. The openings in the screen should

be larger than for tomatoes in order that pieces of plum flesh would be evident in the pulp—a fine grained pulp is not so attractive in appearance and texture as a coarse one.

In preparing plums and apricots for jam making, one factory uses a Sprague–Lowe tomato finisher of the vertical type, equipped with a heavy screen perforated with large (about ¼ inch) oblong openings; the greater diameter of the openings being at right angles to the vertical axis of the finisher. In this machine coarse, heavy brushes rub the flesh through the screen. A coarse pulp is obtained and seeds are well cleaned of adhering flesh.

In English jam factories, a machine similar in general appearance to the Kern tomato finisher is used in preparing plum pulp for jam making. It consists of a perforated horizontal metal cylinder in which coarse brushes revolve rapidly and rub the pulp through the screen. Judging from results, the brush form of pulper (or "finisher") equipped with a screen with about one-eighth inch openings is to be preferred to the tomato pulper for separation of plum flesh from the pits and skins. Tomato finishers and pulpers are standard cannery equipment obtainable from any cannery machinery company. The special screens would probably have to be made to order.

The yields of pulp varied considerably according to the texture of the plums, relative size of pits and length of cooking. The average yield was approximately 159 gallons or about 1430 pounds of pulp per ton of fruit.

Jam was made by boiling the pulp with sugar (and in some cases spices) to the desired consistency in a steam jacketed copper kettle. See figure 3. The usual procedure was to boil the mixture until a boiling point of 220–221° F., as indicated by a jelly thermometer, was reached.

Unspiced jam was prepared in some cases with equal weights of sugar and pulp; in others two-thirds as much sugar as pulp by weight. The use of the smaller proportion of sugar yielded a jellied product when the mixture was cooked to 220–221° F.—whereas the jam made with the larger proportion of sugar usually remained semi–fluid.

When spices were used, they were added after a boiling point of 219 to 220° F. was reached. They were first mixed outside the kettle with about 1 gallon of the hot jam in order to prevent "lumping" of the spices. After addition of the spices, the jam was cooked about two minutes, but not above 221° F.

The following amounts of spices were used to each lot of 150 pounds of pulp and 150 pounds of sugar; one ounce each of cinnamon,

allspice, cloves and ginger. Individual tastes vary and, on this account the flavor of the jam made according to the foregoing formula would not suit all consumers. Plum butter was made in exactly the same manner as the jam except that the boiling was continued until a product of very thick consistency was obtained—this was reached at 223–224° F.

The jam and butter were canned scalding hot in number 2½ plain tin cans, exhausted 6 minutes at 205–210° F. and sealed. No further treatment was given. Sterilization of the sealed product was found unnecessary.

The yield of jam from 150 pounds of pulp and 100 pounds of sugar was 70 number 2½ cans. From 150 pounds of pulp and 150 pounds of sugar the yield varied from 96–110 number 2½ cans, according to the final boiling point of the product.

Peach-Plum Jam and Butter.—In the Placer County plum district there is available a considerable quantity of cull peaches. It was found that the addition of peach pulp to the plum gave a jam of richer flavor than that obtained from plum only.

Hand pitted, lye peeled, pie grade, Tuscan cling peaches were cooked with a small amount of water (same ratio of water and fruit as for plums, i.e., 1:5 by weight) until soft; pulped in a tomato pulper and equal volume of the peach and plum pulps were mixed. An equal weight of sugar was added and the mixture concentrated to a boiling point of 220° F. At this point, to 150 pounds of pulp, was added 1 ounce each of cloves, allspice, cinnamon and ginger as previously described for plum jam, and the mixture heated to 221° F. or to 223–224° F., according to whether a jam of medium consistency or a butter was desired.

The average yield of jam was about 100 number 2½ cans from 150 pounds of pulp and 150 pounds of sugar. In large scale tests cull Elberta and Crawford peaches gave fairly satisfactory results when used with plums in this manner. In smaller scale laboratory tests, the Muir and Lovell were also found satisfactory, in fact, seemed superior to the Elberta. Shipping peaches are picked very green, consequently, lack flavor when box ripened. For this reason, canning peaches of pie grade were found more satisfactory than the cull shipping peaches.

Canned Pulp for Jam.—Plum pulp was prepared on a small commercial scale by the method described for jam making. This consisted in passing the cooked plums through a tomato pulper to separate the pulp from the pits and skins. See figure 2.

The pulp was heated to boiling, canned hot, exhausted 6 minutes at 200–210° F. to expel air bubbles, sealed, processed 13 minutes at 212° F. in an agitating continuous sterilizer and cooled about 2 minutes in running water.

In a typical experiment, 275 pounds of mixed varieties of plums was used and 20.5 gallons (184.5 pounds) of pulp was obtained. To fill 25 number 2½ cans, 47 pounds of the pulp was required. This corresponds to a yield of approximately 761 number 2½ or 228

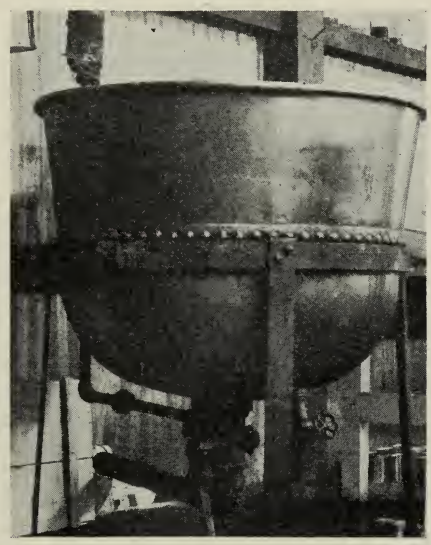

Fig. 3.—Steam jacketed kettle used for heating plums and pulp.

number 10 cans per ton of fresh fruit. The pulp contained 15.5 per cent total solids determined by drying 10 grams in vacuo at 70° C. for 12 hours and 1.74 per cent total acid (as citric) determined by titration of a 10 gram sample with N-10 sodium hydroxide. Pulp from the same fruit to which no water was added contained 19.5 per cent total solids.

The rate of heat penetration in number 2½ cans of plum jam pulp and plum butter were determined by placing the cans in a pot of water maintained at the boiling point and by reading the temperatures at the centers of the cans at regular intervals by means of long stem chemical thermometers. These were inserted through rubber stoppers fitted to openings in the tops of the cans. The following table gives the results of this test.

Rates of Heat Penetration in Number 2½ Cans of Plum Pulp and Plum Butter

Time in minutes	Temperature at center of No. 2½ can of water	Temperature at center of can	
		Plum pulp	Plum butter
0	63° F.	63° F.	63° F.
5	199		
8	205		
30	212	99	80
40	212	122	94
50	212	144	112
60	212	159	129
70	212	172	140
80	212	181	149
90	212	187	177
100	212	192	181
110	212	196	184
120	212	200	188

To reach a pasteurizing temperature of 165° F. about 65 minutes heating was required for the jam pulp and about 85 minutes for the plum butter. Both products heated very slowly because of their thick consistency. Water in a number 2½ can reached the pasteurizing point in less than five minutes.

In commercial practice, the jam pulp and butter would be canned and sealed hot—probably above 180° F. and little or no additional heating would be necessary. If, however, for any reason, such as a temporary shut-down of the cannery, the products were canned cold or allowed to cool before sealing, it would be necessary to heat them at 212° F. for the times indicated by this experiment in order to bring them to 165° F. or above.

The canned pulp was shipped to Berkeley and either used in making jam and butter in the Fruit Products Laboratory, or sold to Berkeley housewives for jam making. On the addition of an equal weight of sugar and boiling to 220–222° F., an excellent jam (or butter) of jelly-like consistency was obtained. Several dozen samples have been stored from July, 1923 to November, 1925—over two years—without loss from corrosion or perforation of the cans. At the present writing, November, 1925, the two year old pulp is still excellent for making jam and butter. However, since the pulp is very high in acid some loss from corrosion of the cans could be expected under commercial conditions after 12–15 months' storage.

Local jam manufacturers state that the pulp is suitable for making jam commercially and that there should be a market for a considerable quantity of it outside of California. It was suggested, however, that a very course screen be used in separating the flesh from the pits and that large cans, number 10, or 5 gallon size, be used.

Berkeley housewives in most instances preferred to purchase the jam and butter instead of making jam in the home from the canned pulp. Nevertheless, a steady demand for it was established by a few demonstration sales on the campus—an indication that the product might be received favorably, even for home use. By the introduction of pectin syrup for home use, housewives have become accustomed to the use of jelly bases; and on this account should be receptive to a jam base in convenient form.

A record was kept of the fruit, labor and cans used in one semi-commercial experiment. The following estimates of cost are based on these data:

Estimated cost of canned pulp from one ton of plums:

1. Fruit, 1 ton	$15.00
2. Cans, 761 No. 2½ at 3.5c	26.63
3. Labor, 1 man 1½ days at $4.00	6.00
4. Cases, labels, steam, etc., estimated at 2c a can	15.22
Total	$62.85
Estimated cost of a No. 2½ can of pulp	8¼c
Estimated cost of a No. 10 can of pulp	27½c

One number 2½ can of pulp gives, with 2 pounds of sugar, approximately seven 6 ounce jelly glasses of jam. At a retail price for the pulp of 15c per can and 7c a pound for sugar, the cost of a glass of jam, exclusive of fuel and the jelly glass is approximately 5.6c. As this is considerably less than the retail cost of ready to serve jam, the use of the jam pulp would be economical. Since it is much more convenient than the fresh fruit for jam making, it should appeal on this score also.

Canned Peach-Plum Pulp for Jam.—Approximately equal volumes of plum and peach pulps prepared as previously described were mixed, heated to boiling, canned and sterilized as described for plum pulp. Many of those who used both types preferred the mixed pulp to the plum pulp and for household use it might prove the more popular. Commercial jam makers, it was found, prefer not to have the two varieties of pulp mixed.

Using 131 pounds of pie grade Tuscan peaches and 151 pounds of a mixture of several varieties of cull plums, there was obtained 93

number 2½ cans of the pulp mixed in the ratio of 108 pounds of plum to 87 pounds of peach. The estimated cost of a 2½ can of pulp was approximately 8¾c and of a number 10 can approximately 29c. Peaches yielded less pulp than plums, because of loss in peeling. Cull Elberta peaches were used in one test, but because of great variation in maturity they were difficult to peel uniformly with lye. The Elberta blended with the plum pulp gave a very satisfactory jam base. Probably cull peaches of any standard variety could be substituted for Tuscan in this formula.

Jelly.—Excellent jelly was prepared on a small scale from each of the following varieties: Wickson, Santa Rosa, Kelsey, Blue California, Blue Diamond, Grand Duke, Burbank, President, Climax and Gaviota.

In a semi-commercial test during the 1923 season, jelly was made from a mixture of approximately equal proportions of Blue Diamond and Burbank plums. To 137 pounds of the mixed fruit in a jelly kettle 9 gallons of water were added and the mixture boiled until the plums were soft—about 15 minutes. The juice was separated from the pulp and pits by straining through sugar bags and was made reasonably clear by filteration through a felt jelly bag. The yield was at the rate of about 200 gallons per ton. The juice on cooling to room temperature was found to contain 1.4 per cent acid (as citric) and to be of 8° Balling. Ten gallons of this juice concentrated with 52 pounds of sugar to 221° F. gave approximately 7½ gallons of jelly. The jelly was pleasing in flavor, clear, red and of firm texture.

The results of these and other experiments demonstrated conclusively that packing house culls of all of the commonly grown varieties of plums of medium or high acidity can be used for jelly making. A red jelly is preferred and, in order to obtain this quality and still make use of varieties lacking in color, it is necessary to add varieties possessing an abundance of color. Such varieties are Blue Diamond, Satsuma, Santa Rosa, Grand Duke and California Blue. The Blue Diamond, because of its high acidity, is particularly desirable for jelly making.

Jelly Juice.—Housewives have learned to use various pectin solutions and powders for jelly making. Jelly manufacturers often store the unsweetened juices from boiled fruits and convert them into jelly as the market demands. The preparation from plums of a jelly juice and its preservation in bottled form for use in jelly making is, therefore, not a new process. The general idea being well known, it should not be difficult to introduce a meritorious plum jelly juice.

During both the 1924 and 1925 seasons, several semi-commercial lots of plum jelly juice were prepared. In one experiment, 25 gallons of water was added to 138 pounds of cull Blue Diamond plums in a large jelly kettle. The water covered the plums to a depth of about six inches. The mixture was boiled 20 minutes and the juice was recovered by straining through double sugar bags. The resulting juice was of 7° Balling and contained 1.1 per cent acid (as citric). In small tests it gave a stiff jelly when boiled to 221° F. with an

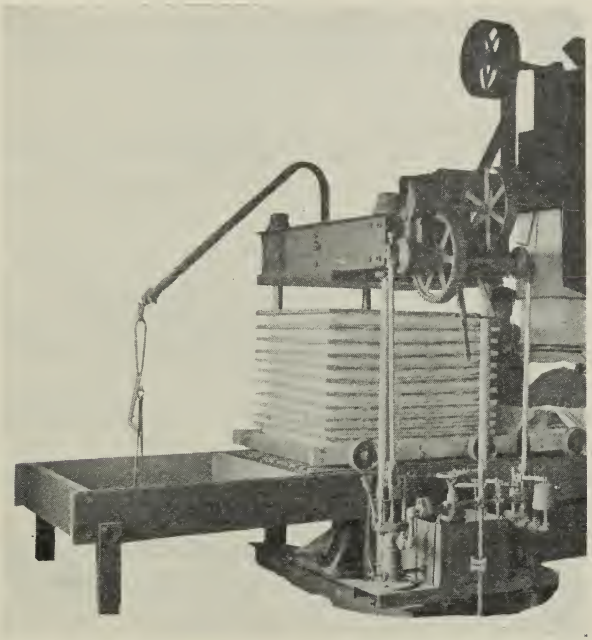

Fig. 4.—Fruit juice press suitable for recovering jelly juice from cooked plums. (Courtesy Hydraulic Press Manufacturing Company).

equal volume of sugar and a soft jelly when boiled 3 minutes with 1½ volumes of sugar. When concentrated to 10° Balling and 1.7 per cent acidity, a firm jelly was obtained by boiling the juice 4 minutes with 1½ volumes of sugar.

From 260 pounds of Blue Diamond culls there was obtained 23 gallons of jelly juice of 10° Balling and 1.7 per cent acidity. This yield is at the rate of 192 gallons per ton. The juice was bottled in 12 ounce bottles and pasteurized at 180° F. for 30 minutes. It was placed on sale in Berkeley successfully.

From a mixture of several varieties of culls (Santa Rosa, Gaviota and Blue Diamond) a jelly juice was prepared essentially as described

above, except that it was concentrated to 20° Balling (corrected for temperature) before bottling. The yield was 80 gallons per ton. This juice was very rich in pectin and gave a good jelly when boiled 3–4 minutes with 2 volumes of sugar.

A third lot was prepared from mixed varieties as described for the Blue Diamond juice, except that it was concentrated to only 8° Balling. It gave an excellent jelly when boiled "to the jelling point" (220° F.) with an equal volume of sugar.

From the results of these and other experiments it is concluded that the best method of preparing jelly juice from cull plums is as follows: Use a mixture of varieties of which at least 50 per cent by weight consists of blue or black or red varieties. To each 150 pounds, add about 25 gallons of water. Boil until soft. Press the fruit and strain the resulting juice. A rack and cloth press is satisfactory for pressing. See figure 4. Concentrate the juice until it will test 10° Balling (corrected for temperature); 10° Balling at room temperature corresponds to about 2° Balling if the test is made at or near the boiling point. Filter the juice. Bottle in crown finish bottles. Seal. Pasteurize in water at 180–185° F. for 30 minutes.

To use for making jelly, add an equal volume of sugar and boil to the jellying point.

It will be noted that 10° Balling is recommended, although experiments proved that a juice of 8° Balling would give a good jelly. Plums vary considerably in pectin and acid and it is desirable, therefore, to add a safety factor of 2° Balling.

Candy and Candy Base.—Plums are rich in pectin and acid, and, on this account, plum pulp when cooked with the proper proportion of sugar gives a very firm jelly–like product suitable for coating with chocolate or sugar as a confection.

Plum pulp was prepared as previously described for jam and was then concentrated to approximately one–half its original volume in order to increase the pectin content. One part by weight of this candy base with one part of sugar cooked to 222°–223° F. gave on cooling, a very firm product which could be cut into suitable form for use as candy. For dipping in chocolate it was found desirable to pour the hot liquid into starch molds as candy manufacturers do with other "jelly center" candies, and to dry the centers a short time at 120–130° F. so that the surface would be dry enough to take the chocolate coating satisfactorily. Moisture causes the chocolate to turn gray.

In addition to using the concentrated pulp in preparing candy, it was canned boiling hot without the addition of sugar. The cans were

sealed and sterilized at 212° F. for 15 minutes. The canned pulp has kept satisfactorily for two years and its jellying power has not noticeably decreased during storage.

A candy base was also prepared with equal volume of unconcentrated Elberta peach pulp and plum pulp (from mixed varieties), plus 1 per cent by weight of powdered apple pectin containing 80 per cent of pectin. The pectin was dissolved in water before addition to the pulp. This product also gave satisfactory jelly centers when concentrated to 222–223° F. with an equal weight of sugar. The unsweetened pulp was canned in the same manner as the plum candy base and has retained its jellying power and flavor satisfactorily for two years.

The inner surface of the cans shows considerable etching after two years' storage, and one per cent of the cans have become hydrogen swells. After one year's storage, there was very little evidence of action on the tin plate and there were no hydrogen swells.

At the present time, most candy makers use starch, agar agar and gelatin in preparing jelly centers. Some make use of fruit pulp with or without the addition of jellying substances. A large proportion of glucose is used in such candies and is desirable because it prevents crystallizing. Several manufacturers stated that they have used plum pulp for jelly centers and found it satisfactory. Its use for candy centers is, therefore, not entirely new and possibly it could be introduced to the commercial manufacturers as well as to housewives.

The candy base is excellent for jam if 1½ to 2 parts of sugar is added to 1 part by weight of the pulp and the mixture cooked to the desired consistency. Because of its double utility it should appeal particularly to housewives.

Its cost is moderate. The yield of plum pulp concentrated 2:1 is about 100 gallons, or about 400 number 2½ cans per ton of fresh fruit. With fruit at $15 per ton, 400 cans at $14.00, labor estimated at $6.00 and other costs at 2c per can or $8.00 per ton, the cost for 400 cans of pulp would be $43.00, or about 11c a can. One number 2½ can yields about 3 pounds of candy. At a retail cost of 20c per can for the pulp and 15 cents for the sugar used, the cost of materials for 1 pound of candy would be about 12 cents.

The plum candy is pleasing in flavor and, because of its acidity and large proportion of fruit, should be more wholesome than plain sugar candies. Because of its cheapness, ease of utilization, pleasing flavor and health appeal, the canned candy base should find favor, if not for commercial use, at least for home use.

Possibly for confectioner's use the pulp should be concentrated with glucose and cane suger to the jellying point, poured into forms and allowed to solidify to slabs, dusted with powdered sugar or starch and packed in boxes between parraffin paper. The confectioner would then have only to cut the slabs into pieces, roll them in sugar and pack in boxes for sale. This was done experimentally.

Syrup for Beverage and Table Use.—From several varieties of plums which yielded red juices, syrups suitable for fountain and for domestic use were prepared. Syrup made from white varieties was not very attractive in appearance.

Because of its very high acidity and deep color, the Blue Diamond variety was used in a semi–commercial scale experiment, although in a small scale test the Satsuma was found to give a syrup of more pronounced flavor.

Approximately 300 pounds of the plums were placed in a jelly kettle with water to cover (about 10 gallons) and heated to 180° F. for 30 minutes. This softened the fruit thoroughly and caused the water to dissolve the color from the skins. The hot mixture was placed in sugar bags of double thickness and allowed to drain about 15 hours. The juice so obtained was filtered through a jelly bag. The yield was at the rate of about 160 gallons per ton of fresh fruit. It would have been considerably greater if pressure could have been applied.

The juice was of 8° Balling and contained 1.25 per cent acid (as citric) ; juice expressed from crushed whole plums of another variety (Grand Duke) not admixed with water was of 17° Balling and 1.45 per cent acid.

To this juice sugar was added to increase the Balling degree from the original 8° to 35° Balling. It was sealed cold in 12 ounce crown finish bottles and hot in number 10 cans and pasteurized at 180° F. for 40 minutes. The juice in the bottles retained its color satisfactory for more than a year, but that in the tin rapidly changed to a muddy, light blue color. Bottled unsweetened juice did not retain its flavor and became rather astringent. The addition of sugar appears to be necessary.

The sweetened juice made an excellent beverage when diluted with 3 volumes of water and served ice cold. It was served in this form at the hotel soda fountain in Lincoln and proved popular. It was much improved by the addition of 10 to 20 per cent of fresh orange juice. Because of its high acidity and deep color, it was found to be a good base for fruit punches.

In preparing the fountain syrup on a commercial scale, it is recommended that a glass lined or aluminum kettle instead of copper be used for heating the fruit in order to avoid loss of color, and that the juice be recovered from the heated fruit by pressing in a rack and cloth press instead of by draining through bags. See figure 4. Filtration through cotton filter pulp in a Kieffer, Cellulo or similar filter would give a clearer juice than was obtained by filtration through a felt bag.

It is believed that the following estimates of the cost of materials and manufacture are conservative.

Item	Estimated cost of syrup per quart bottle
Fruit at $20.00 per ton and yield at 175 gallons per ton	2.9c
Sugar, 0.6 lb. at 7c per pound	4.2c
Bottle at 5c	5.0c
Manufacturing cost (labor, power, etc.)	2.5c
Case, label, wrapping, etc.	4.0c
Total	18.6c

Because of its succesful trial sale as a fountain beverage at Lincoln, it is believed that a considerable quantity of sweetened juice could be sold in the Sacramento and San Joaquin valleys for use in preparing summer beverages, for fountain and home use.

In addition to its suitability for beverage purposes, the syrup would be excellent for use in gelatin desserts, fruit cocktails, pudding sauces (when thickened with starch) and for making jelly when pectin (such as Certo) and sugar are added.

Canning.—Some of the plums, particularly those too small for fresh packing, but free from blemishes, and those too ripe for fresh shipment, are satisfactory for canning purposes. Several varities were canned, of these the Giant, on account of its large size and relatively low acidity, was the most satisfactory. The President, the Grand Duke, Santa Rosa, Wickson and Kelsey plums and the Sugar prune gave good dessert fruits when canned.

In some experiments sweet varieties, such as the Giant plum and sugar prunes were canned in plain syrup of 40° Balling and the sourer varieties, such as the Grand Duke, Santa Rosa and President in 50° Balling. The fruit softens during sterilizing, and, on this account, the sterilizing period should be short—not more than 10 minutes at 212° F.—and cooling after sterilizing should be thorough. An exhaust of 6 minutes at 200–210° F. was used.

In some experiments, spiced syrup was added to the fruit at the time of canning. The spiced plums were preferred to the unspiced

by those who sampled them. Because of their natural high acidity, it is not necessary to add vinegar to the spiced syrup as is done with peaches and pears. The recommended procedure is as follows:

Sort, wash and can the fruit. Add a syrup of 40° Balling previously spiced by heating to boiling 20 gallons of syrup with 12 ounces of ginger root, 14 ounces of whole cloves, 18 ounces stick cinnamon and 14 ounces whole allspice, allowing to stand 8–12 hours and straining through cheese cloth to remove the spices. Exhaust 6 minutes. Seal. Process 8–10 minutes at 212° F. and cool thoroughly.

Preserves.—The sour varieties of plums gave fairly satisfactory preserves when boiled a short time, 4–5 minutes, with an equal weight of sugar and barely enough water to prevent scorching. The fruit was allowed to stand overnight in the syrup formed during cooking in order to permit absorption of the syrup by the fruit. The preserves were packed in 4 ounce and 8 ounce vacuum sealed jars and sterilized at 185° F. for 40 minutes.

It was found by A. W. Christie that most varieties could be peeled in the same manner as tomatoes—that is, by hand after heating in boiling water about 3 minutes and chilling in cold water. The peeled fruit was used experimentally in making preserves as described above and for packing in glass in a spiced syrup. This syrup was made with 16 pounds of sugar, 3 pints of 40 grain vinegar and 7 pints of water. To this quantity of syrup were added 1 ounce of ginger root, 2 ounces whole cloves and 3 ounces of stick cinnamon. The syrup and spices were brought to boiling for 2 or 3 minutes and allowed to stand overnight. The plums, both peeled and unpeeled, were heated to boiling in this syrup and allowed to stand overnight. They were then packed in vacuum sealed jars and sterilized at 185° F. for 30 minutes.

Plum preserves and jams are not in such great demand as those made from berries; nevertheless, the plum products are good for table use and can be made more cheaply than the berry products on account of the low cost of the cull plums. If sold at a low price, a considerable quantity of plums might be disposed of in the form of preserves and jam.

*Dehydration**.—Nine varieties of plums from Placer County were dehydrated experimentally and the cooking quality of the dehydrated products determined. The Santa Rosa, Blue Diamond, Wickson and Climax gave satisfactory dried products, with the Santa Rosa ranking

* The experiments on dehydration were made by Professor A. W. Christie, to whom thanks are due for data on dehydration used in this publication.

first in quality. The Burbank, Kelsey, Grand Duke and Giant gave only fair results, while the California Blue was very poor in quality after drying.

The fruit used in these experiments was picked green for Eastern shipment and allowed to ripen in the crates. If allowed to ripen on the trees, it would have become richer in sugar and, therefore of better drying quality.

The immaturity of the fruit was reflected also in the yields; the drying ratios (ratio of fresh to dried weights) were high, varying from 4.3:1 to 6.8:1, averaging 5.3:1. French prunes average about 2.3:1.

In preparing the plums for drying, it was found desirable to dip them in a boiling dilute lye solution (about ½–¾ of 1 per cent) to check the skins. Exposure of the lye dipped fruit to the fumes of burning sulphur for 30–60 minutes retained the natural color of the fruit and checked darkening.

A drying temperature of 150° F. was found best. Higher temperatures caused "bleeding" of the fresh fruit and darkening near the end of the drying period. In order to have the fruit keep well, the moisture content of the dried product must be low because the low sugar content of the fruit renders it susceptible to molding.

The cost of dehydrating would probably be about the same per green ton as for prunes, although greater per dry pound, because of the higher drying ratio of the plums. A. W. Christie estimates the direct dehydrating cost at about 1 cent per pound and costs of maintaining a plant, processing, packing, selling, etc., at 4–5 cents per dry pound additional. On this basis, the dried plums would have to sell wholesale at 10 cents a pound to return the grower $15.00–$20.00 per green ton.

Dehydrated plums would probably have to compete with dried prunes and, since the plums require the addition of sugar and prunes do not, they would be at a considerable disadvantage. However, the dehydrated plums are excellent as a raw material for the making of jam, jelly and preserves and for use in pies—for which the sweet varieties of dried prunes are not well adapted. Like all new products, dehydrated plums would require advertising to introduce them successfully.

SUMMARY AND CONCLUSIONS

1. *List of Products.*—During the 1923, 1924, and 1925 seasons various products were prepared from cull shipping plums. A list of these products and estimated cost of each is given in the accompanying table.

Product	Container recommended	Estimated cost of production
Frozen crushed plums for jam and jelly.	5 gallon tins and 50 gallon barrels.	2½c per pound or 22c per gallon.
Butter and jam	No. 1 tall and No. 10 cans; 8 oz. and 16 oz. jars.	No. 1 tall can 7.5c; No. 10 cans 69c; 8 oz. jar 6c; 16 oz. jar 11c.
Plum jam pulp	No. 2½, No. 10 and 5 gallon cans.	No. 2½ can 8¼c; No. 10 can 27½c; 5 gallon can $1.50.
Plum-peach jam pulp	No. 2½, No. 10 and 5 gallon cans.	No. 2½ can 8¾c; No. 10 can 29c; 5 gallon can $1.55.
Jelly	8 oz. and 16 oz. jars; No. 10 cans.	8 oz. jar 7c; 16 oz. jar 11c; No. 10 can 80c.
Jelly juice	12 oz. bottles; quart bottles and 5 gallon lacquered cans	12 oz. bottle 5c; quart bottle 13c; 5 gallon can $1.70.
Candy	1 pound boxes	15c per pound.
Candy base	No. 2½ and No. 10 cans	No. 2½ can 11c; No. 10 can 35c.
Beverage syrup	Quart and gallon bottles	Quart 18.6c; gallon 68c.
Preserves	8 oz. and 16 oz. jars	8 oz. jars 7c; 16 oz. jar 11c.
Canned plums	No. 2½ cans	No. 2½ can 8–10c.
Dehydrated plums	1 pound and 5 pound cartons	1 pound carton 9–10c; 5 pound carton 43–47c.

2. *Freezing Storage.*—Cull plums may be crushed in an ordinary apple crusher and packed in barrels or 5 gallon cans and stored indefinitely at a freezing temperature for use in jams and jellies. After removal from storage the fruit will keep at least one week in 50 gallon barrels. This makes possible its transportation to considerable distances without additional refrigeration. This method is recommended above all others for preserving plums for use in jam factories on the Pacific Coast.

3. *Butter and Jam.*—Cull plums of sound quality are as good as higher priced first quality plums for use in jam and butter and should find a considerable market for use in low priced jams and butters. Cull shipping peaches may be used with the plums to advantage.

4. *Jam Pulp.*—A low priced jam pulp suitable for home and factory use may be prepared from cull plums by heating until soft

and pulping through a coarse tomato pulper screen or, preferably, a special very coarse screen in a tomato pulp finisher. This product could probably be retailed for 15 cents per No. 2½ (quart) can. Peach pulp from cull shipping peaches added to the plum pulp improves the flavor.

5. *Jelly.*—Cull plums are perfectly satisfactory for jelly making. Varieties yielding red juice high in acidity such as Blue Diamond, Santa Rosa, Satsuma and California Blue are recommended in preference to white varieties.

6. *Jelly Juice.*—A low priced, but excellent juice for jelly may be prepared from cull plums by cooking the fruit, extracting the juice as for jelly making and pasteurizing it in bottles for home and factory use. Sugar is added by the user.

7. *Candy and Candy Base.*—Plum pulp concentrated 2:1 makes an excellent candy center when cooked to 222° F. with an equal weight of sugar. The pulp may be canned without sugar for use by confectioners and housewives. Jam pulp may be used for the same purpose.

8. *Beverage Syrup.*—Red plum juice sweetened with cane sugar to 35° Balling is an excellent base for summer beverages. It should find a ready market in the hot interior valleys of the State.

9. *Preserves.*—Both plain and spiced preserves of good quality can be made from unblemished cull plums by standard formulae.

10. *Canning.*—Several varieties of unblemished cull shipping plums were found thoroughly satisfactory for canning for dessert purposes. A spiced syrup is recommended. The larger varieties are probably to be preferred for canning.

11. *Dehydrated Plums.*—Most varieties of cull plums give fairly satisfactory dehydrated products, but the yield is low. The dried fruit is very tart and requires the addition of sugar when cooked for sauce or jam.

Recommendations

It is recommended that plum growers and shippers arrange with existing fruit products establishments for the trial production of several of the most promising products described in this bulletin and that their marketability and profitability be determined by trial sales.

For such trials frozen plums in barrels, plum butter, plum jam pulp, plum jelly juice and plum beverage syrup are recommended. These products are listed in the order of their supposed desirability and chance of commercial success.

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